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ABSTRACT

Until recently national manpower policies and programs have focused relatively little attention on the more skilled and better educated segments of the labor force. The concept of "manpower" has emphasized the training and placement of the disadvantaged. But a comprehensive manpower program must focus on the employment problems of individuals at all levels of occupational structure. Two critical aspects of the manpower problems of scientific and engineering personnel are their present substantial unemployment and the long-range equation of supply of and demand for educated manpower, both quantitatively and qualitatively. The welfare of the nation rests more heavily on the relatively small numbers of professional personnel, particularly scientists and engineers, than on any other occupational group. The effective development and utilization of talent and competence represent a challenge to the nation equal in importance to providing training and employment opportunities for the disadvantaged, and the federal government bears responsibility for both. The document presents policy directions to make the development, conservation, and utilization of scientific and engineering talent an integral part of a comprehensive national manpower policy. (MF)

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Manpower Policy for SCIENTISTS and ENGINEERS

E. WIGHT BAKKE

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MANPOWER POLICY FOR SCIENTISTS AND ENGINEERS

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FOREWORD

The last time I saw E. Wight Bakke was at a meeting of the National Manpower Policy Task Force on November 18, 1971, in Washington, at which a draft of the present paper was discussed. A few days later he died in his sleep, bringing to a sudden end a most distinguished career in labor economics. At the time of his death he was Sterling Professor of Economics at Yale University which had been his academic home for more than a third of a century.

Bakke was always a pioneer, from his pathbreaking studies of the unemployed during the depression of the 1930's to this last effort, in which he extends the reach of manpower policy to include a concern with educated, particularly scientific and engineering, manpower. He never doubted that a truly comprehensive labor market policy must include provisions for all the members of the labor force, in fact, for the entire population of working age, since every human being has the potential for making a contribution through work to his society, and every responsible society has the obligation to provide optimal opportunities for all its citizens to work productively.

Bakke was the principal author of the successive drafts of the present paper, although he had the advice and counsel of three colleagues, Frederick Harbison, Charles Myers, and M. H. Trytten. Final work had not been completed at the time of his death, and the Task Force had not reached a final decision about the specifics of the statement or its policy recommendations. But Bakke's unexpected passing and Trytten's resignation created a new situation for the Task Force, and subsequently my colleagues entrusted me with the task of preparing for publication Bakke's last draft with his penciled annotations, which had been made available by Mrs. Bakke. I gladly assumed this task as a token of friendship for an esteemed co-worker for whose work and values I have long had the deepest admiration.

In preparing the paper for publication I have been guided by two principles: to let Bakke's ideas and formulations which were developed and polished remain untouched; and to make usually small, but occasionally large, changes mostly in the form of deletions where I knew this able craftsman anticipated further change and improvement. I have indicated in the notes and com-

ments my more radical editorial decisions and the reasons for them. I have tried conscientiously to keep my own views, and those of the other Task Force members, from intruding where they are in disagreement with Bakke's thoughts.

One question remains: to what extent do the members of the Task Force agree with the thrust of Bakke's analysis? They believe, with Bakke, that the development, conservation and effective utilization of scientific and engineering manpower should be an essential element in any comprehensive national manpower policy. The Task Force members, however, differ on the choice of policy options which are raised for discussion at the end of the paper. These deserve further study and consideration, but, with Bakke unable to contribute his wisdom and his warmth to such discussion, the Task Force decided to note that differences remain. We are proud to make public this last contribution of our friend and colleague, E. Wight Bakke, whose good works continue even after his death.

Eli Ginzberg

February 1972

INTRODUCTION

The National Manpower Policy Task Force in its January 1969 policy statement, "The Nation's Manpower Programs" included a section on scientific and professional manpower.[1] We believe that there is a need at the present time to review the policies affecting this group with an aim of determining how its contribution can be maximized in seeking the full employment of our nation's human resources in the pursuit of the individual and collective goals of the American people.

Until recently, national manpower policies and programs have focused relatively little attention on the more skilled and better educated segments of the labor force. The effort to synchronize the numbers and qualifications of persons with baccalaureate and higher degrees with the need and demand for their services has had relatively low priority. Although the federal, state, and local governments through their financial support for colleges and universities and for low income students impact directly on the future supply of educated persons, the concept of "manpower," as operationally defined by the programs of the U.S. Department of Labor, has emphasized the training and placement of the disadvantaged members of the labor force. It does not detract from the importance of this latter objective to assert that a comprehensive manpower program must focus on the employment problems of individuals at *all* levels of occupational structure.

The Short and the Long of It

There are two critical aspects of the manpower problems of scientific and engineering personnel—one immediate and short range; the other, continuing and long range.

The first is present substantial unemployment and the inexcusable wastage of human resources which this represents. The federal government must bear a large degree of responsibility for this situation. And certainly, the avoidance of such wastage now and in the future is a proper function for federal policy.

The second critical aspect is the long-run match-up of the supply of and demand for educated manpower, in both quantitative and qualitative terms. If our national goals are to be met, this match-up should not be left to chance, or to market forces poorly adapted to achieving a timely balance for manpower whose preparation involves a long lead time. The federal government has a role to play to supplement private manpower planning to assure that the trained personnel needed to achieve long range national goals are available.

Justification

The justification for focusing attention on scientific and engineering manpower lies in the critical role of this group in the production of goods and services essential to national strength and human welfare. The welfare of the nation, its quality of life, and its protection from within and without rests more heavily on the relatively small numbers of professional personnel, particularly scientists and engineers, than any other occupational group. The nation cannot remain indifferent to the forces governing their development and utilization without placing its own future in jeopardy.

The nurturing and conservation of scientific and engineering talent are objectives equal in importance to the national interest (and clearly instrumental to) assisting disadvantaged workers. For example:

1. Scientists and engineers play key roles in the processes of production in a sophisticated technological economy. They are largely responsible through their role in research and development for innovations and new directions for industrial progress and advances in productivity.
2. Insofar as a favorable balance of payments is an important ingredient in the nation's economic health and in its capacity to provide expanding employment opportunities, it should be noted that our chief foreign trade advantage is in the export of science-based goods and services.
3. Improvements in the quality of American life in the future is heavily dependent on the problem-solving efforts of scientists and engineers in such critical fields

as urban renewal and reconstruction, ecological restoration, population-resources equilibrium, and natural resource maintenance.

4. Finally, there are important international goals to the achievement of which scientists and engineers are directly and critically related, such as the maintenance of American intellectual leadership, assuring that the United States maintains requisite political, economic, and military strength among the world powers, and enabling this country to provide technical assistance to the developing nations.

SECTION I

The Immediate Problem

The evidence concerning current (late 1971) employment of educated manpower, particularly scientists and engineers, is not reassuring. Unemployment has increased dramatically in certain occupational groups, industries, and geographic regions, reflecting in considerable measure reductions in expenditures for defense and space, compounded by a slack civilian economy.

The Case for Action

The recent dramatic change in the labor market for professional personnel, notably scientists and engineers, has been frequently described, sometimes in lurid language. The hard facts are disquieting. Since January 1969 the employment outlook for highly trained manpower has changed dramatically, and in some respects catastrophically. On the basis of the figures released by various federal agencies in mid-1971 it is possible to make a rough estimate of the number of unemployed scientists and engineers. One datum reports 150,000 unemployed scientists, engineers, and technicians. If technicians account for about half of the total, then the number of unemployed scientists and engineers approximates 75,000. The Bureau of Labor Statistics calculates the total college educated scientific and engineering work force as 1.5 million which would mean that they have an unemployment rate in the range of five percent.[2]

To provide a more up-to-date picture of unemployment among scientists, especially those at the doctorate level, the National Science Foundation sent a questionnaire in the spring of 1971 to 300,000 persons included in the 1970 Register of Scientific and Technical Personnel. A similar questionnaire was distributed to engineers.[3] The major findings showed a substantial rise in unemployment for both scientists and engineers over the year from 1.5 percent to 2.6 percent for scientists and from 1.6 percent to 3 percent for engineers. Over half the unemployed scientists were in Physics or Chemistry, the unemployment rates averaging 3 percent for Chemistry and 3.9 percent for Physics, approximately double for the rates for 1970. Research and development represented the previous work activity of three-fifths of the unemployed scientists compared to two-fifths of all registrants. About 45 percent of the

unemployed reported their last science-related employment was supported at least in part from federal funds. The report shows unemployment among scientists increasing steadily. Of the 6,300 unemployed scientists, more than half had lost their jobs since January 1, 1971. The average length of time that they had been out of work was seven months.

Federal Responsibility

The moral issue presented by the widespread unemployment of scientists and engineers is one which the federal government cannot ignore. The National Science Foundation estimates that the jobs of about 2 out of 5 scientists and engineers depend on federal appropriations. Other studies point to the fact that 3 out of 5 aeronautical engineers depend on federal programs for their employment. Of the approximately 2 million scientists, engineers and technicians employed at the beginning of 1970, approximately 1 in 4 was engaged in work generated by the Department of Defense, the National Aeronautics and Space Agency, or the Atomic Energy Commission.[4] With the federal government's programs absorbing a substantial percentage of the total employable labor force in specific occupational groups any sudden decline in support for such programs will result in the discharge of such large numbers of persons with specialized capabilities as to preclude their reabsorption. The elasticity of the labor market for professional personnel can adjust to marginal variations in supply or demand but it cannot meet the challenge of large-scale discharges resulting directly from a change in federal policy.

Changes in federal policy are clearly responsible for most of the present difficulties. The abrupt shift in the federal government's priorities, resulting in the winding down of the Indo-China conflict, the reduction in defense expenditures, the sharp cuts in NASA's budget, and the abandonment of development work on supersonic aircraft, has been reflected in a marked weakening of demand for scientists and engineers as was highlighted in the 1971 *Report of the Council of Economic Advisors.*[5]

The industrial and geographical concentration of employment of scientific and engineering manpower in federally supported projects resulted in a corresponding concentration of

unemployment when federal support was cut back. Between 1967 and 1971 the Boeing Company let go approximately half of all its employees with college degrees.[6]

Technical personnel in the twin fields of defense and aerospace have been especially vulnerable to the decline in employment opportunities. Their expertise is often so highly specialized as to make lateral transfers to other industries difficult or impossible. Moreover they are often far distant from the centers of civilian work which means that even if jobs are available they require painful adjustments in living arrangements.

Coincident with the drop in employment for professional personnel in defense and aerospace industries, there has been less federal support for academic scientific activities. The total decline in real dollars has been on the order of 4 percent, but adjustments within the total resulted in much larger declines for certain types of scientific and engineering work.

Federal programs that employ large numbers of educated persons are inherently vulnerable to sudden shifts in the political arena and as such manifest more instability than programs that depend on the profit-seeking proclivities of private entrepreneurs. But that makes more urgent the need for preventative and rehabilitative action by the federal government. Because the government is largely responsible for the current plight of scientists and engineers, equity calls for remedial public action.

To this end, the White House announced in April 1971 an allocation of $42 million to assist unemployed scientists, engineers, and technicians who were victimized by the defense-aerospace cutbacks to help them find new jobs. The federal government is to be commended for recognizing its obligation to assist these unemployed persons to whose distress it so directly contributed. But this effort is inadequate.[7] Much more can be done in the short run to alleviate the problems posed by the abrupt reduction of federal programs and its untoward impact on professional personnel and reduce the wastage of valuable human resources by salvaging to the maximum degree possible their skills and talents for constructive use.

Some Reservations

That the federal government has responsibility for providing short-term relief to scientists and engineers is not accepted in all quarters. The arguments against any special efforts question the allocation of limited resources to those who possess many more options than the disadvantaged beneficiaries of manpower policy and programs. While it is true that the rate of unemployment for the educated group has increased dramatically, it is still far lower than the national average and only a small fraction of the rate for the disadvantaged. Professional people are also better positioned to take care of themselves during a period of reduced employment opportunities and have the edge on others in searching for and obtaining employment. Since they have more resources at their disposal, it might be considered inequitable to divert scarce governmental funds to their assistance in lieu of helping more vulnerable persons. While job opportunities supported by federal projects like defense procurement, space, transportation, and R. & D. fluctuate, so do job opportunities in other sectors of the economy. Those accepting employment underwritten by federal dollars were aware of the risks involved, accepted them, and were compensated for them in the form of higher salaries. Finally, critics may contend that it is inequitable to assist those at the top of the talent ladder while neglecting the rest of the work force that is subject to the same instabilities. This inequity will have to be taken into account in the design of any viable long-range plan.

Appraisal of the Reservations

The question of relative economic need will inevitably be raised in decisions involving the allocation of scarce national resources. There is no firm evidence to substantiate or negate most of the assertions outlined above. The better educated group is better positioned to find a job but it is an assumption, and nothing more, that they will be more successful in a job search when the market for their skills has collapsed.

While those higher on the occupational ladder are likely to have more assets than production workers, neither group benefitted significantly for the "special risk" of accepting employment on government supported projects. Most of them have not been employed long enough to build up a significant degree of

economic security. In spite of current mythology, they did not enjoy unusual salary benefits. For example, the annual salary survey conducted by the Engineering Manpower Commission for 1970 shows median salaries for nonsupervisory engineers with 12 years of experience amounting to $15,700, only $500 below the earnings of comparable staff in aerospace. Similarly, the NSF *Reviews of Data on Science Resources* (NSF 70-50, No. 19, December 1970) shows median salaries for atmospheric and space sciences to be almost exactly the average for all scientific and technical fields. The myth of high salaries in government supported work is not borne out by the facts.

The reservations to broadening the focus of manpower policy and programs to include a major concern for high-talent manpower are compelling only if one accepts a limited view of federal manpower policy. These reservations see the primary, if not exclusive, objective of manpower policy to relieve human distress resulting from lack of employability. This is certainly a major objective, but not the sole one. Equally important is the full development and utilization of the creative potential of *all* members of the labor force. The nation has a stake in the full development and efficient functioning of the *total* manpower system, not only in remedial assistance for those who are most vulnerable. *The effective development and utilization of talent and competence represent a challenge to the nation equal in importance to providing training and employment opportunities for the disadvantaged.* The government bears a heavy responsibility for both.

SECTION II

The Long-Range Problem

The long-range mission of manpower policy is to assure the nation an adequate supply of workers of all types needed in the production of goods and services essential for achieving national objectives. High-talent manpower plays a crucial role in meeting these objectives, and care must be taken that short-range efforts to eliminate an oversupply of scientists and engineers do not undermine the longer range goal.

The Case for Action

The lead time for the education and training of scientists and engineers, is four to eight years beyond high school. It is necessary, therefore, to consider requirements for such manpower well in advance of their availability for employment. The art of manpower forecasting is not well developed. No precise numbers of trained personnel required to meet future demands can be determined. However, there are at least three developments which strongly suggest that needs may expand dramatically in the future, much more than incremental projections would suggest. These developments are in addition to the fact that our national defense is increasingly dependent on an adequate supply of competent scientists and engineers.

The Dynamics of Science and Technology

New products and new processes depend increasingly on scientifically oriented research and development and on advances in technology to exploit the breakthroughs. The nature of future breakthroughs cannot be predicted, but as the base of scientific knowledge broadens and deepens, more scientifically trained manpower is required to press ahead on research and development and to exploit the discoveries as they are made.

For example, there was no way to calculate ahead of time the large numbers of scientists and engineers required to develop and utilize atomic fission. New breakthroughs are on the horizon in physics, chemistry, biology, oceanography, the exploration of space, the utilization of solar energy; but once again, we cannot calculate the scientific and engineering manpower requirements that they will call forth.

The only prediction that can be safely made on the basis of experience is that the need for scientifically trained manpower expands with every scientific discovery. The "labor saving" impacts of advances in science and technology do not reduce the need for scientists. Indeed, the profound changes which are taking place in employment patterns in this "age of science" and growing impact of science and technology on all aspects of human endeavor presage burgeoning demands for high-talent personnel.

The Role of Science and Engineering in Ecology

The warnings are loud and clear concerning the threats to human welfare and survival from the world-wide pressures of exploding population, limited food resources, diminishing supplies of energy resources, and the pollution of the environment. The basic knowledge to meet these threats must come mainly from science and scientists. It is true that public pressure for action has not yet reached the point which compels government to reorder their resource allocations to meet these threats. At present, there is no shortage of manpower to attack these problems because there are no budgets.

But the pressure is mounting, and it is not the course of wisdom to estimate the future demand for scientists and engineers who must be in the vanguard in meeting these critical needs on the assumption of a continuing public apathy and lack of concern for the dangers that they and their children face. The lead time for producing these scientists and engineers is sufficiently long that the future is *now* as regards decisions affecting manpower supply.[8]

These basic problems are in many respects world-wide, and in assessing the manpower resources required to work on them one should consider not domestic need but the priority requirements of countries whose scientific and technical cadres are limited. It is not too much to expect a leading world power to assist them by providing specialized manpower.

But our domestic need is sufficiently great to encourage action now so that we will not experience a critical shortage in the future. One can already foresee that sooner rather than later every state and municipality will need to establish and man

departments concerned with environmental protection. In addition to the high visibility of environmental problems, other issues of local concern requiring the increased employment of scientists and engineers can be identified: the management of waste, urban planning, improved transportation.

Science and Engineering: A Comparative View

With world-wide recognition that science, scientists, and engineers play a critical role in national development, economic well-being, and defense capability, the leading powers are acting to strengthen their scientific resources. Every since Lenin, the Soviet Union has allocated large sums for education and the support of science.[9]

Whether or not competition in armaments and space exploration are vital to our national purpose, a cavalier disregard for the integrity of the nation's manpower resources in the relevant scientific and engineering specialties, and untoward fluctuations in the level of national effort in these fields, can prove to be as dangerous as it has proved to be expensive.

Need for Basic Policy for Science and Technology

In one sense, to emphasize the lack of national manpower policy with respect to scientific and technological personnel is to put the cart before the horse. For a policy for more effective scientific manpower development and utilization should be predicated on the prior determination of long-range policy for science and technology with budget allocations consistent with the goals of that policy. The lack of federal policy for science and technology, as well as for a corollary manpower policy, was recognized at hearings before the Committee on Science and Astronautics of the House of Representatives in mid-summer 1970. The Chairman, Emilio Daddario, reported after the hearings that the testimony showed the "the nation has no formalized science policy to guide it."[10] At that same hearing the then Head of the Office of Science and Technology, Dr. Lee DuBridge, conceded "there is now no national policy for the support and promotion of science and technology" and that his office had inadequate manpower for an intensive study of the matter.

There is lacking a governmental initiative for the promotion of science and technology, and for federal guidance to the private sector. There is also lacking a long-range federal policy with respect to the support for scientific education and research to assure adequate training and employment opportunities for the nation's cadre of scientists and engineers.

Some Reservations

There is a direct relation between the output of our colleges and universities and the supply of high-talent manpower. Hence those who propose changes in federal manpower efforts aimed at assuring the nation an adequate flow of qualified scientific personnel in the future must take account of the several studies which suggest that we now have too much high-talent manpower (specifically at the Ph.D. level) and that the oversupply will continue for some time.

The report of the National Science Foundation (NSF 71-20) issued in May 1971 entitled *1969 and 1980 Science and Engineering Doctorate Supply and Utilization* comes closest to providing the federal government's view of the employment market for recipients of scientific and engineering doctoral degrees.

The report projects past trends and concludes that by 1980 there may be a general oversupply of 10 percent of doctorate personnel. The calculated supply lies between 315,000 to 336,000 against projected openings of 270,000 to 297,000. The maximum discrepancy could be of the order of 270,000 openings and 336,000 available degree recipients or an oversupply of 20 percent; the minimum projected discrepancy would be 315,000 graduates for 297,000 openings or an oversupply of 6 percent.

There are, however, marked differences in the outlook for engineering and science. Using the middle range of projections, there may be a 40 percent surplus of engineering doctorates in 1980. In contrast, the report concludes that there is likely to be a stand-off between supply and requirements in the physical sciences with some imbalances developing in mathematics and the life sciences that may face oversupplies in the 10 percent range.

Other studies, however, differ in their conclusions and recommendations. In a paper entitled "Scientific Manpower for 1970-1985,"[11] Chancellor Allan Cartter of New York University concludes from the ground swell of graduate enrollments relative to the modest expansion of faculties that the country faces a period of growing oversupply of doctorate holders over the next fifteen years, especially in the academic market.[12]

In his paper, "Manpower in Science and Engineering Science,"[13] Wallace Brode considers the situation over a longer time span and is less sanguine about the adequacy of the future supply. His analysis is based on a "saturotire model," which he defines as the maximum percentage of college age students (approximately 4 percent) who are likely to have the interest, aptitude, and ability to select and pursue science or engineering as a career choice. Dr. Brode acknowledges the likelihood of a surplus of doctorates in the present decade and into the eighties but foresees a sharp decrease thereafter in college and graduate enrollees with the requisite potential. He therefore concludes that policies aimed at limiting the output at the doctorate level because of the near term oversupply could lead to disastrous consequences in the longer run.

A report by the Department of Labor on the outlook for educated manpower projects for the seventies projects a rough balance between the supply and demand for college graduates.[14] There are differences, however, among the several specialties. Engineering, physics, chemistry are likely to show small deficits. In the natural sciences, only the life sciences and mathematics are likely to be plagued with overages.

Appraisal of Reservations

Several important assumptions underlie the analysis of those who see an oversupply of trained manpower. They stipulate that the requirements for high-talent manpower will be determined by small and slow changes in the present technology, in the context of existing scientific knowledge, in the present organization of work, and in the light of entrenched private and public priorities.

Specifically, the projections by Cartter and the Department of Labor indicating the probability of an oversupply of Ph.D.'s in the future are based on "the types of employment we

have known in the past." But we have postulated that the recognized but still largely unmet needs of our society will require many scientists and engineers with new knowledge and techniques if effective programs are to be implemented. Admittedly some of the existing stock can be retrained to meet these new demands but if the past is any guide the leadership will come from recent graduates.

There are other reasons for questioning the shaping of public policy based on the "fear" of an oversupply of highly educated manpower. The improvement in the quality of junior colleges and secondary schools through staff additions of well trained graduates who cannot find positions in universities, should be viewed as an opportunity.[15] Such staff additions, if they can be financed, can strengthen the basis for those who will go to work after high school and live in a world in which technology plays a dominant role.

Finally the pessimistic statistical projectors have unquestionably failed to take adequately into account the extent to which the higher reaches of management in both the private and the public sectors will be interested in adding well-trained persons to their staffs. They will have need for many more scientists and engineers if they are to implement the many science-based programs that will provide a base for profit making and for gains in the general welfare.

And while it is inevitable for manpower analysts to deal with *number* of personnel available and the *number* of job openings, they should not lose sight of the critical role that *quality* plays in performance.

The societal needs to be satisfied by high-talent manpower are served to an exceptional degree by the quality of mind and skill of those capable of creative work through applying a disciplined and insightful imagination to the discovery of new knowledge and useful techniques. Increasingly, the human resources for such creative work are not individual geniuses, but teams of competent scientists and engineers who have demonstrated the ability to perform. A manpower policy must be aware of the large numbers of young people who must be afforded opportunities to develop their potential if a small number of geniuses and a larger number of competent research and development teams

are to emerge. Moreover manpower policy must be sensitive to the conditions that must be established and maintained if talented individuals and groups are to remain productive.

Another weakness in current assumptions is the tendency for statistically inclined analysts to work with narrow categories both as to fields of training and employment. They seek balances or imbalances within narrow parameters disregarding the flexibility characteristic of educated persons in the labor market. An important correction to the assumption of one-to-one relation between degree holders in a particular field and future requirements for that particular field is suggested by new information becoming available about career mobility patterns.

It is not true that most scientists follow a straight career path from their undergraduate major through their adult career. Many move within and between fields both during training and employment. A sound educational system will stress the type of preparation that can contribute to their future mobility. And one of the strengths of our system has been a tradition of loose coupling between specialization in undergraduate or graduate school and a man's field of employment.

The stereotype of the individual who goes through a long period of training, perhaps including four years or more of graduate education, receives a Ph.D. degree and then moves into a position of teaching or research in his chosen field where he remains throughout his career is more observable in the breach than in the fact.

Field-to-field mobility is particularly high where breakthroughs occur. The 1964 National Register included only 86 persons with degrees in solid state physics, with only 46 reporting themselves as working in the field. But there are 1,894 Ph.D. holders working as solid state physicists: of these, 1,388 were Ph.D. recipients in Physics other than solid state; 318 held doctoral degrees in Chemistry; 109 in Engineering, and 33 in other disciplines.

A tight labor market will unquestionably lead to increased mobility among highly trained persons. However, one must be careful not to assume that because a man cannot work in the field of his specialization he will fail to make a satisfactory occupational adjustment or fail to contribute commensurate

with the heavy investments that were made in his education and training. This may be the outcome but it need not be. Many who move out of their field of specialization turn out to be high performers.

In summary, it is clear that those who calculate a future oversupply of high-talent manpower have made use of questionable assumptions including:

1. Estimating future demand on a projection of present trends.
2. Postulating that employment opportunities for graduate degree holders will be expanded only slowly because of the inertia of social systems.
3. Ignoring the demands that are certain to arise from new fields of science and new areas of application because these demands cannot be quantified.
4. Underestimating the demands that will be generated by breakthroughs in established scientific and technological fields.
5. Postulating that students enrolling in a particular scientific discipline aim to carry on a career only in the same field.
6. Neglecting the potential adaptability of educated persons to make their way even in the face of adverse market conditions in their own field.
7. Failing to appreciate that graduate education opens opportunities to people for a productive career and life other than in the field of their subject matter training.

Choice in the Face of Uncertainty

These reservations with respect to manpower forecasting are serious. They place both the proponents and opponents of specific action in the role of prophet—a role that fits neither the scientist nor the responsible government official. But even without the gift of prophecy, each man must make his best judgment about the future since the actions or non-actions that he advocates now will determine his society's ability to cope with what may come. If nothing is done, there is a risk that the future will find us poorly prepared to meet a large, although not precisely predictable, need and opportunity involving high-talent manpower. On the other hand, if actions are taken on the

assumption that the future need will be substantial and that need does not materialize, we may face even more severe unemployment, underutilization, and waste than we do today. The answer is to chart a course which makes use of statistical and analytical studies but also allows for probable changes emerging from the advances of science and technology and the desires of people and nations to improve the quality of their lives. We live in a world of uncertainty, and the art of manpower predictions is admittedly limited. But that does not justify a policy of inaction. We have not delayed designing and implementing programs for the hard-to-employ until all, or even most of the necessary data were at hand. Rather we moved ahead a step at a time, collecting and analyzing new data as they became available, while we sought to strengthen our programs for manpower training and other services. We believe that this is the way we should proceed with respect to programs for educated manpower; to delineate the best possible programs in terms of available knowledge, while always taking a positive stance toward the future. We dare not run the risk of a shortage of the people best able to contribute to the solution of the nation's problems.[16]

SECTION III

Policy Options[17]

The thrust of this position paper has been that the development, conservation and effective utilization of scientific and engineering talent must be an integral part of a comprehensive national manpower policy. Such an effort should be viewed as of equal importance with programs for aiding the disadvantaged and broadening the base of opportunity for education and training. Scientific and engineering manpower is a critical national resource that can be nurtured and strengthened to sound policies and programs.

The precise directions for action require public attention and debate. As a contribution thereto, the following policy directions have been formulated:

1. *With respect to the development of a science policy:*

   a. Congress should declare the support and promotion of science and the financing of graduate education as national goals.
   b. The federal government should seek to develop a "stable funding policy" for basic research at universities and other institutions so that work can proceed without seriously disruptive fluctuations in financing.
   c. The Office of Science and Technology should be strengthened and a Council on Science and Technology established.
   d. A National Institute of Research and Advanced Studies might be established to administer federal support of scientific research and of the newly organized "think tanks" which are directed to exploring how science and technology can be used to help solve urgent national problems.
   e. A federal grant-in-aid program might be established to encourage the hiring of scientific and engineering manpower for natural resource planning.

2. *To strengthen the federal government's data collection, planning and analysis of scientific and engineering manpower:*

   a. An Office of Scientific, Professional, and Engineering Manpower could be established in the U.S. Department

of Labor's Manpower Administration which would have responsibility for broad policy and programmatic overview, including continuing liaison with other agencies of the federal government and with nonprofit and private organizations having planning and operational concerns in this area of scientific manpower.

b. Each federal department or agency with programs requiring the use of large numbers of scientific and engineering personnel might establish an Office of Manpower Analysis and Projection for its own guidance and to serve as liaison, including regular reporting, to the central Office of Scientific, Professional and Engineering Manpower in the U.S. Department of Labor.

c. The collection and analysis of data about educated manpower can be strengthened by both the Department of Labor and other federal agencies, with an aim of improving projections of future demand and supply; dissemination of such studies to interested groups inside and outside the federal government should be improved.

d. A section of the President's *Manpower Report* could be regularly devoted to an analysis and evaluation of problems of educated manpower.

3. *To strengthen the federal government's manpower programming for scientific and engineering personnel:*

a. Those elements of the Spring 1971 $42 million program for special assistance to unemployed and underemployed scientists and engineers involving job search, mobility allowances, job retraining, etc., which prove worthwhile might be funded at appropriate levels on a continuing basis.

b. The federal-state employment service might be strengthened by expanding counseling and job development services for educated manpower, and by improving and expanding its placement services at scientific meetings.

4. *With respect to facilitating the education and training and retraining of scientific and engineering manpower:*

a. Research and development grants might be considered for selected universities to develop core and cross-disciplinary curricula which will facilitate the career

mobility of science and engineering students.

b. Similar grants might be provided for the development of models to prevent the obsolescence of knowledge and skills of educated manpower.
c. Initial and some continuing funding might be provided for the establishment at selected universities of research and teaching institutes which would focus on the application of science and technology to the solution of urgent environmental and related problems.
d. A long-range policy of support for selected programs of graduate and professional education might be instituted; including a system of merit fellowships to encourage exceptionally able young people to enter new and promising careers.
e. Funding might be provided for "retooling" unemployed scientists and engineers for new fields with high public interest and need, such as natural resource management, pollution control, and other areas in which job opportunities are open or are likely to open in the future.
f. Consideration might be given to establishing a contributory federal government-contractor insurance program to provide payments during periods of unemployment and for re-education of scientific and engineering manpower displaced by cutbacks in federally funded research and development activities. Such a program might be designated as "The National Fund for Development and Conservation of Talent."
g. Federal funding might be provided to state and local governments to enable them to hire retrained scientists and engineers who are unemployed. Such unemployed specialists might also be given preference for jobs funded under various federal grant-in-aid programs which require their technical skills.

NOTES AND COMMENTS

1. The author used the working title "High Talent Manpower Policy" and defined scientists to include both "natural and social scientists." A careful reading of his *Third Draft* indicates that his primary focus is on scientific and engineering manpower, the term adopted for publication.

2. A Bureau of Labor Statistics report lists the following distribution of college graduates:

Chemists	130,000
Engineers	1,100,000
Geologists and geophysicists	30,000
Mathematicians	70,000
Physicists	45,000
Life Scientists	168,000
	1,543,000

3. *Unemployed Rate for Scientists*, Spring, 1971, NSF 71-26. About 85 percent responded, representing about half of the total pool of scientists. The resulting unemployment estimates are definitely on the low side. Also, *Unemployment Rate for Engineers in June and July of 1971*, NSF 71-33.

4. Mottur, Ellis, *Conversion of Scientific and Technical Resources*, Program of Policy Studies, George Washington University, Monograph No. 8, March 1971.

5. This *Report* indicated that by the third quarter of 1970, defense purchases had declined by 18 percent from their peak in the second quarter of 1968, and that during fiscal year 1971 the total numbers employed by defense purchases decreased by 1.8 million workers.

6. Stanley Little, Director of Industrial Relations for the Boeing Company, reported in June 1971 that from 1967 (approximately the date of maximum employment) total employment dropped from 168,000 to 54,000 and by the end of 1971 it will have dropped another 10,000. Among those with college degrees, the corresponding decline was from 22,000 to 11,000 with another 2,000 scheduled to be released by the end of 1971.

7. The program provides funds for retraining, job search, mobility allowances, and a wide range of additional services including the development of an unemployment register, special counseling, and research on skill conversion.

8. What the future may hold in respect to the need for human resources in specialties requiring advanced education and training can be glimpsed from a study by the National Science Board in June, 1971 entitled *Environmental Science—Challenge of the Seventies*. While noting that there has been a sharp rise in the vigor and development of environmental science, the report observes: "Environmental science, today, is unable to match the needs of society for definitive information, predictive capability, and the analysis of environmental systems as systems. Because existing data and current theoretical models are inadequate, environmental science remains unable in virtually all areas of application to offer more than qualitative interpretations or suggestions of environmental changes that may occur in response to specific actions." The report points to two reasons for this state of affairs: "(1) The natural environment is not a collection of isolated events and phenomena but rather a vast, integral, mutually interacting system. (2) The trained scientific manpower available to meet the challenge is extremely

limited in each of the essential aspects of environmental science." The report sums up by stating, "The situation constitutes a crisis for the nation. While environmental problems are so diverse and diffused that virtually every activity of civilization interacts with the environment, few persons can be aware of the full scope of challenge that lies ahead. The current mismatch between capability and need is at least comparable to any other challenge to science and technology that was encountered during this century!"

9. According to Dr. John S. Foster of the Department of Defense, the higher education establishments of the U.S.S.R. are graduating consistently and increasingly more scientists and engineers that the U.S. by a factor of roughly two to one.

10. *Toward a Science Policy for the U.S.*, House Committee on Science and Astronautics, GPO 1970.

11. *Science*, April 9, 1971.

12. Cartter calculates a demand for doctorates other than for teaching of about 130,000. He calculates the demand for academic employment as between 80,000 and 125,000 depending on evolving educational standards. The resulting "demand" is likely to fall between 210,000 and 255,000. He estimates the production of the graduate schools will be between 325,000 and 375,000 by 1985.

13. *Science and Engineering Science*, July 16, 1971.

14. The report projects total annual baccalaureates increasing by 48 percent between 1968 and 1980. Degrees at the master's level and the doctoral level are projected to increase by 95 percent and 117 percent respectively. This means a total of 13 million degrees to be awarded between 1968 and 1980—10.2 million bachelor's degrees, 2.7 million master's degrees, and 400,000 doctoral level degrees.

15. Cartter anticipates that the surplus of doctoral graduates will "bump" those with lesser degrees from positions in junior colleges and high schools.

16. There were two pages in the author's draft entitled "Too Much Science Already?" which have been eliminated because the argument was not fully elaborated and further was not integrated with the preceding analysis or the recommendations which follow. Bakke argued that no matter what, science and technology would be aggressively pursued for reasons of defense and the best hope for correcting its excrescences lay with the scientists themselves.

17. While I have substantially reordered what the writer referred to as "Action Options" I have not added or subtracted any material from his draft except as noted here: The introductory statement is based on a recommendation of his collaborator, Professor Harbison; and the last two recommendations—4f and 4g—represent a reformulation and addition recommended by Professors Harbison and Myers.